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Bioenergy in a Greenhouse Mitigating World

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Agriculture may help mitigate climate change risks is by helping reduce greenhouse gas (GHG) emissions. One way of doing this is by providing substitute products that can replace fossil fuel intensive products or production processes. Production of biofeedstocks for bioenergy achieves this, where the biofeedstocks are traditional products, crop residues, wastes or processing byproducts. The forms of bioenergy include electrical power or liquid transportation fuels e.g. ethanol or biodiesel.

Employing agricultural products in such a way generally involves recycling of carbon dioxide (CO2), a greenhouse gas, because plant growth absorbs CO2 while combustion releases it. This is likely to mean that emission permits would not be needed for the CO2 emissions that arose when generating biofeedstock fired electricity or consuming liquid biofuels.

GHG permit prices could raise the market value of agricultural commodities as long as bioenergy use does not require acquisition or use of potentially costly/valuable emissions permits. Consequently, biofeedstocks may be a way that both: (a) energy firms can cost effectively reduce GHG liabilities and (b) agricultural producers gain agricultural income. But, before wholeheartedly embracing bioenergy as a GHG reducing force, one must fully consider the GHGs emitted when raising feedstocks, transporting them to a plant and transforming them into bioenergy. One must also consider the market effects and possible offsetting effects of production stimulated elsewhere. Two issues arise when taking on such a viewpoint

- What are the GHG offsets obtained when using particular forms of bioenergy and what does this mean for comparative economics of feedstocks?
- When bioenergy production reduces traditional commodity production does the market reaction of other producers reduce net GHG effects?

This paper briefly discusses these issues and is largely drawn from a longer version of the paper by McCarl (2008).

Lifecycle Accounting and Biofeedstock Economics

The net GHG contributions of a bioenergy production possibilities depend upon the amount of fossil fuel used in the project lifecycle from production until use including emissions generated when: (a) making production inputs, (b) producing the feedstock, (c) hauling it to a facility and (d) processing it into fuel or electricity. This contribution varies by feedstock, type of energy developed and region of the country since hauling costs depends on yield and density of production. Table 1 displays a consistent set of estimates across a number of possibilities for use of

- crop or cellulosic ethanol in place of gasoline,
- biodiesel in place of diesel and
- biofeedstock fueled electricity with sole firing and 5% cofiring

using data from regions commonly discussed as having high potential for feedstock production.

The data within Table 1 show the percentage direct reduction in carbon dioxide equivalent emissions.

The table shows for example that the percentage reduction in net GHG emissions when using corn-based ethanol is 17% relative to using gasoline. This means 83% of the potential emissions savings from replacing the gasoline are offset by the emissions from the use of fossil fuels in producing the corn, transporting it to the plant and transforming it into ethanol. We also see higher emission offset rates for electricity principally because the feedstock is burned with little transformative energy needed once it is at the generation site. Also cofiring generally has a higher degree of offsets because hauling distances are shorter as lower feedstock volumes are required and because of the

	Form of Bioenergy being Produced				
	Liquid Fuels			Electricity	
Feedstock Commodity being used	Crop Ethanol	Cellulosic Ethanol	Biodiesel	Co fire at 5 %	Fire with 100% biomass
Corn	17%				
Hard Red Winter Wheat	16%				
Sugarcane	65%				
Soybean Oil			95%		
Corn Oil			39%		
Switch Grass		57%		86%	75%
Corn Cropping Residue		70%		89%	80%
Wheat Cropping Residue		56%		93%	87%
Manure				99%	96%
Bagasse		96%		98%	96%
Lignin				91%	86%

Table 1. Percentage Offset of Net GHG Emissions from the Usage of a Biofeedstock.

hotter burning caused by the presence of coal which increases feedstock heat recovery.

Broadly across the table, we see

- Relatively lower rates for liquid fuels as opposed to electricity.
- The lowest liquid fuel offsets arising for grain based ethanol with relatively higher values from cellulosic ethanol and biodiesel from soybean oil.
- Results that reflect differential offset rates due to the differential use of
    - Emission intensive inputs in producing feedstocks (corn is a large fertilizer user).
    - Emission intensive transformation processes in making ethanol along with successively less so processes to make cellulosic ethanol, biodiesel and electricity.

Such results portend that economically if higher greenhouse gas prices were to arise that there would be a shift in production away from grain based ethanol toward cellulosic and a trend to move toward electricity. Analysis by McCarl and Reilly shows such trends.

Leakage – Offsets from Elsewhere

Beyond the direct GHG impacts of bioenergy there are offsite concerns. Namely, market forces such as today's high corn prices (rising principally because of the rapidly rising amount of corn being converted to ethanol) can cause net GHG emission reductions within one region to be offset by increased emissions from expanded production in other areas of the world or portions of the economy (Murray, McCarl and Lee; Lee et al; Fargione et al, Searchinger et al). Today it is common to hear about many forms of such offsets (typically called leakage in international GHG settings) being stimulated by high agricultural commodity prices including

- U.S. forested acres being harvested and converted to cropland,
- Possible reversion of Conservation Reserve Program lands into cropland or
- Expansions of crop acres in Brazil and Argentina at the expense of grasslands and rainforest (Lee et al, Searchinger et al) .

Key factors in the size of this leakage as discussed in Fargione et al, McCarl and Murray, McCarl and Lee, include

- The amount that marketed production that is offset. Note use of residues and waste product feedstocks lower this while use of conventional commodities raises it.
- The land use that replacement acres come from and the embodied emissions. Large offsets occur when rainforest or forest or possibly CRP land is involved.
- The supply responsiveness of competitive areas.
- The market share of the country producing the bioenergy.

McCarl constructs leakage estimates based on a formula by Murray, McCarl and Lee show international leakage easily offsets nearly 50% of the domestic diverted production when GHG offsets per acre are equal and an even higher share of the net GHG gains if acres with higher emissions are involved. Along this line Searchinger et al show that when acres are directly replaced by rainforest reductions, that net GHG emissions would increase. Fargione et al point out the risks of emission increases varies under different land uses and feedstocks along with the desirability of using waste products.

It is also important to note that market forces may also cause reductions elsewhere where for example commodity price increases for feed may reduce livestock production and accompanying emissions as covered in McCarl.

Concluding Remarks

This paper discusses several major points relative to bioenergy and greenhouse gas offsets

- Not all bioenergy forms have equal direct greenhouse gas offset effects. Generally grain based ethanol provides the least offsets, then cellulosic, then biodiesel, and then electricity.
- Leakage created by market price induced replacement production overseas and domestically is an important factor and can offset domestic GHG emission reduction gains substantially. There is a high degree of uncertainly as to

the magnitude of the leakage but it is expected to be significant. Less leakage occurs when biofeedstocks are used which do not divert market production.

- Economically as GHG prices rise the more desirable bioenergy forms become bioelectricity and cellulosic ethanol.

From a policy perspective the arguments above indicate that bioenergy and greenhouse gasses are complexly intertwined and that current promotion of items like corn ethanol may not in fact be contributing much to greenhouse gas reductions. In fact, recent papers argue that this reliance may well be leading to net increases when the global consequences are considered. Certainly U.S. GHG reduction policies need to be carefully formulated as they can be ineffective, even having the opposite effect, if global and competing land use changes are not considered. Leakage, per unit GHG offset and market displacement appear to be lessened with reliance on residue and waste products in addition to emphasis on cellulosic ethanol and electricity.

For More Information

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